METEOROLOGICAL MEASUREMENTS IN THE VICINITY OF A COAL BURNING POWER PLANT

Gennaro H. Crescenti[1*]

Atmospheric Sciences Modeling Division
Air Resources Laboratory
National Oceanic and Atmospheric Administration
Research Triangle Park, North Carolina

John E. Gaynor

Environmental Technology Laboratory
National Oceanic and Atmospheric Administration
Boulder, Colorado

1. INTRODUCTION

High concentrations of sulfur dioxide (SO_2) are commonly observed during the cool season (November to February) in the vicinity of a coal burning power plant located in the Mae Moh Valley of northern Thailand. These high pollution fumigation events occur almost on a daily basis, usually lasting for several hours between late morning and early afternoon. One-hour average SO_2 concentrations are commonly observed in the range of 1000 to 2000 :g m^{-3}. As a result, an increase in the number of health complaints have been observed by local clinics during this time of year.

In order to understand the atmospheric processes which are responsible for these high pollution fumigation events, meteorological data were acquired from a variety of observing platforms during an intensive field study from early December 1993 to mid-February 1994. Data were acquired in the vicinity of the power plant from SO_2 gas analyzers, in-situ sensors mounted on a 100-m tower, a single-beam monostatic sodar, a three-axis monostatic sodar, radar wind profiler, and a radio acoustic sounding system (RASS). These data will also be used in the future to initialize and verify dispersion models. This paper briefly describes the meteorological measurements made in the Mae Moh Valley during the winter of 1993/1994.

2. DESCRIPTION OF THE PROBLEM

The power plant, operated by the Electric Generating Authority of Thailand (EGAT), is located in the Mae Moh Valley about 25 km east of the Changwat Lampang Province in northern Thailand (Fig. 1). The valley is about 15 to 20 km wide, 50 km long, and is aligned from northeast to southwest. The valley floor is relatively flat with an average elevation between 320 and 360 m above sea level (asl). Two ridges parallel the valley on either side. To the northwest, the hills average 700 m asl; to the southeast, 900 m asl. To the northeast, the valley is also enclosed by hilly terrain. To the southwest, the valley opens to the Changwat Lampang Province. The valley is sparsely populated, with the largest concentration of people living in several small villages south of the power plant. The valley is primarily used for agriculture, with the predominant crops being rice and sugar cane.

The coal burning power plant was constructed in several phases over the last two decades in the center of the valley to take advantage of a nearby lignite reservoir. A total of eleven separate power generators in two separate facilities produce approximately 2.025 GW of power, supplying about a quarter of Thailand's electricity. The three stacks of the first facility (Units 1, 2, and 3) are 80 m high, while the eight stacks of second facility (Units 4 through 11) are 150 m high. The base of all eleven stacks are 320 m asl. While electrostatic precipatators are present in each unit to remove particulates, there are no pollution controls (i.e., scrubbers) to remove SO_2. Since there are no other major industrial activities in the Mae Moh Valley, the power plant is the source for nearly all of the observed SO_2 (Saengbangpla et al., 1981; 1982).

The number of health complaints have increased during the cool season when high concentrations of SO_2 have been observed at numerous monitoring stations in the vicinity of the power plant. These high pollution fumigation events, which occur on almost on a daily basis, last for no more than several hours, usually starting in the late morning and ending by early afternoon.

---

[1]On assignment to the Atmospheric Research and Exposure Assessment Laboratory, U. S. Environmental Protection Agency.
[*]Corresponding author address: Gennaro H. Crescenti, U.S. EPA, AREAL, MD-56, Research Triangle Park, NC 27711.

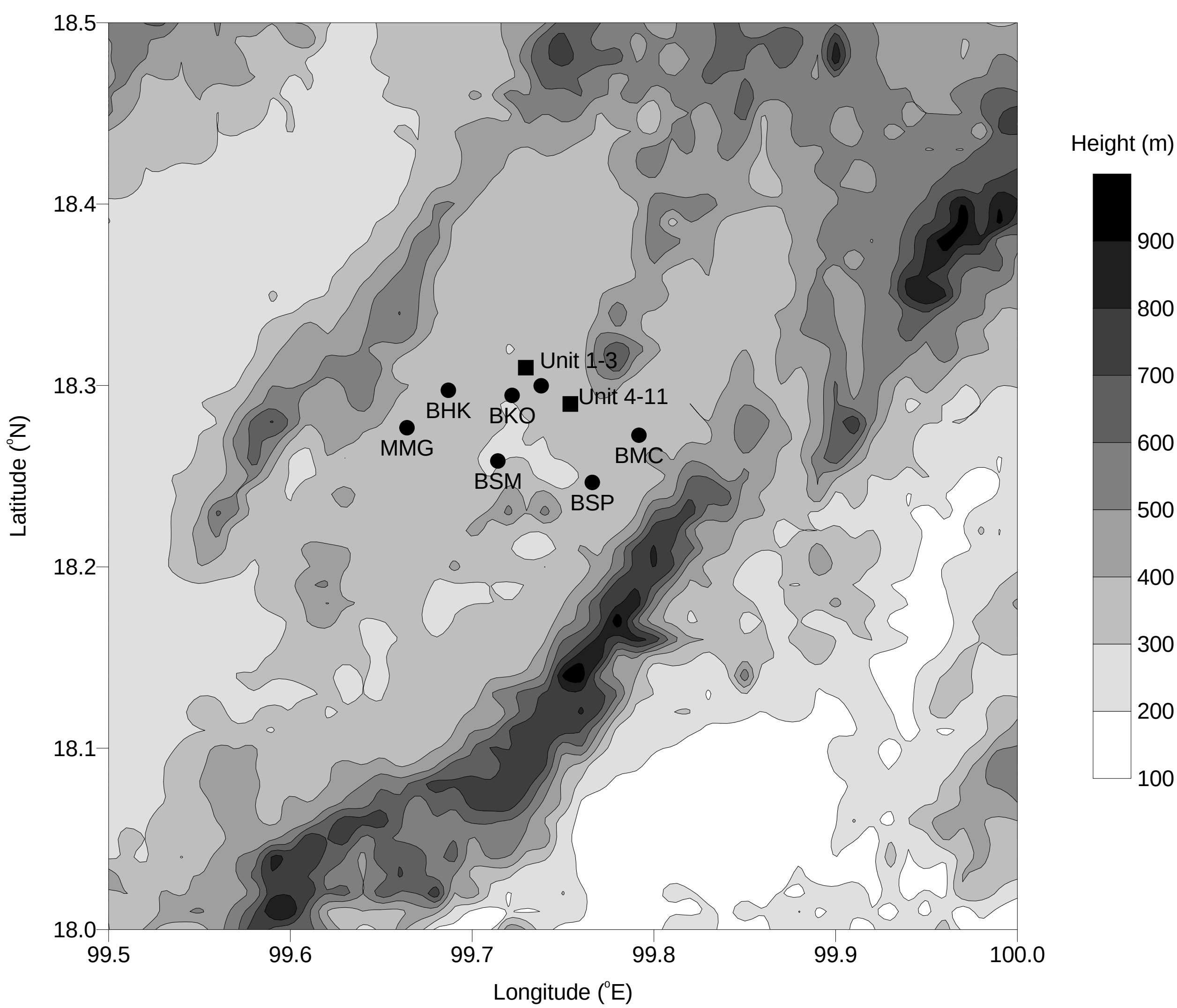

Figure 1. Topographic map of the Mae Moh Valley. The power plant is represented as the two squares. SO_2 monitoring stations are depicted by the circles. The unlabeled circle between the two squares is the 100-m tower located at the main meteorological station (MMS).

3. MEASUREMENTS

SO_2 and meteorological data were acquired from the beginning of December 1993 to mid-February 1994. These data set are described below.

3.1 *SO_2 Measurements*

SO_2 measurements were acquired by Thermo Environmental Instruments (model 43A) pulsed fluorescent ambient air analyzers at seven surface monitoring sites ranging from 1 to 8 km from the power plant. These SO_2 sites were located at Ban Mae Chang (BMC), Ban Sop Moh (BSM), Ban Sop Pad (BSP), main meteorological station (MMS, 100-m tower), Ban Ko-Or (BKO), Ban Huai Khing (BHK), and the Mae Moh Government Center (MMG). These data were reported through a radio telemetry link to a computer located in an EGAT office near the power plant as ten-minute averages. A typical fumigation event is depicted in Figure 2 for three of the SO_2 monitoring stations.

3.2 *100-m Tower Instrumentation*

An existing suite of Weathertronics (a division of Qualimetrics) in-situ sensors were used to obtain

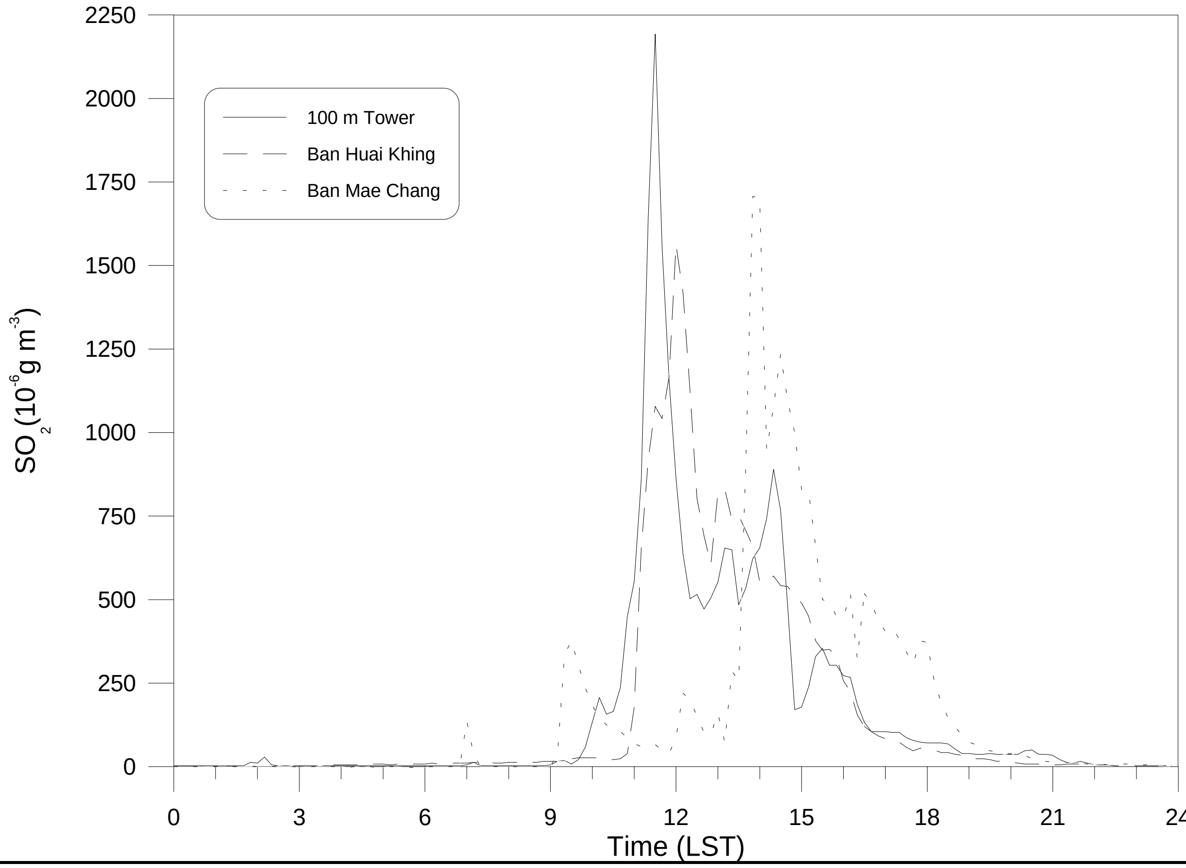

Figure 2. SO_2 concentrations (: g m^{-3}) observed on 1 January 1994 at the 100-m tower, Ban Huai Khing, and Ban Mae Chang.

meteorological data from the 100-m tower for the field study. Ambient air temperature was measured at 2, 10, 50 and 100 m by a thermistor (model 4480). This sensor was housed inside an aspirated radiation shield to minimize the measurement errors associated with solar heating. Horizontal wind speed and direction were measured at 10, 50, and 100 m by a cup anemometer (model 2030) and vane (model 2020), respectively. Vertical wind velocity was measured at 10, 50, and 100 m by a propeller anemometer (model 2070). These data were acquired by a Sum-X data logger as one-hour averages.

A new suite of in-situ meteorological sensors were installed on the 100-m tower for the field study. Ambient air temperature and relative humidity were measured at 2, 10, 50 and 100 m by an R. M. Young Company (model 43372C) relative humidity temperature probe. This dual sensor was housed inside an R. M. Young (model 43408) Gill aspirated radiation shield. Horizontal and vertical wind velocity were measured by an R. M. Young (model 27005) Gill UVW propeller anemometer at 10, 50, and 100 m. Global solar radiation was measured near the surface by an Eppley Laboratory Precision Spectral Pyranometer (model PSP). These data were acquired by a Campbell Scien-tific (model CR-10) data logger over 15-min intervals.

Wind velocity and turbulent flux measurements were obtained by an Applied Technologies sonic anemometer (model SWS-211/3K). The sonic anemometer was mounted at 10 m on the 100-m tower. A program written in BASIC on a 386 PC was used to interrogate the sonic anemometer at 10 Hz and average those data over 15 min intervals. These data included the mean of the three component wind velocity (U, V, W) and virtual air temperature (T_v); standard deviation of the three component wind velocity (F_u, F_v, F_w) and virtual air temperature (F_T); resultant mean wind speed and wind direction (WS, WD); and covariances of U and V, U and W, V and W, U and T, V and T, W and T. A one-week time series of some 10-m in-situ data are shown (Fig. 3).

3.3 *Single-Beam Monostatic Sodar*

A 2 KHz single-beam monostatic sodar (NOAA designed and built) was located about 3 km to the west of the 100-m tower and about 1 km to the northwest of Ban Ko-Or. This remote profiler continuously recorded

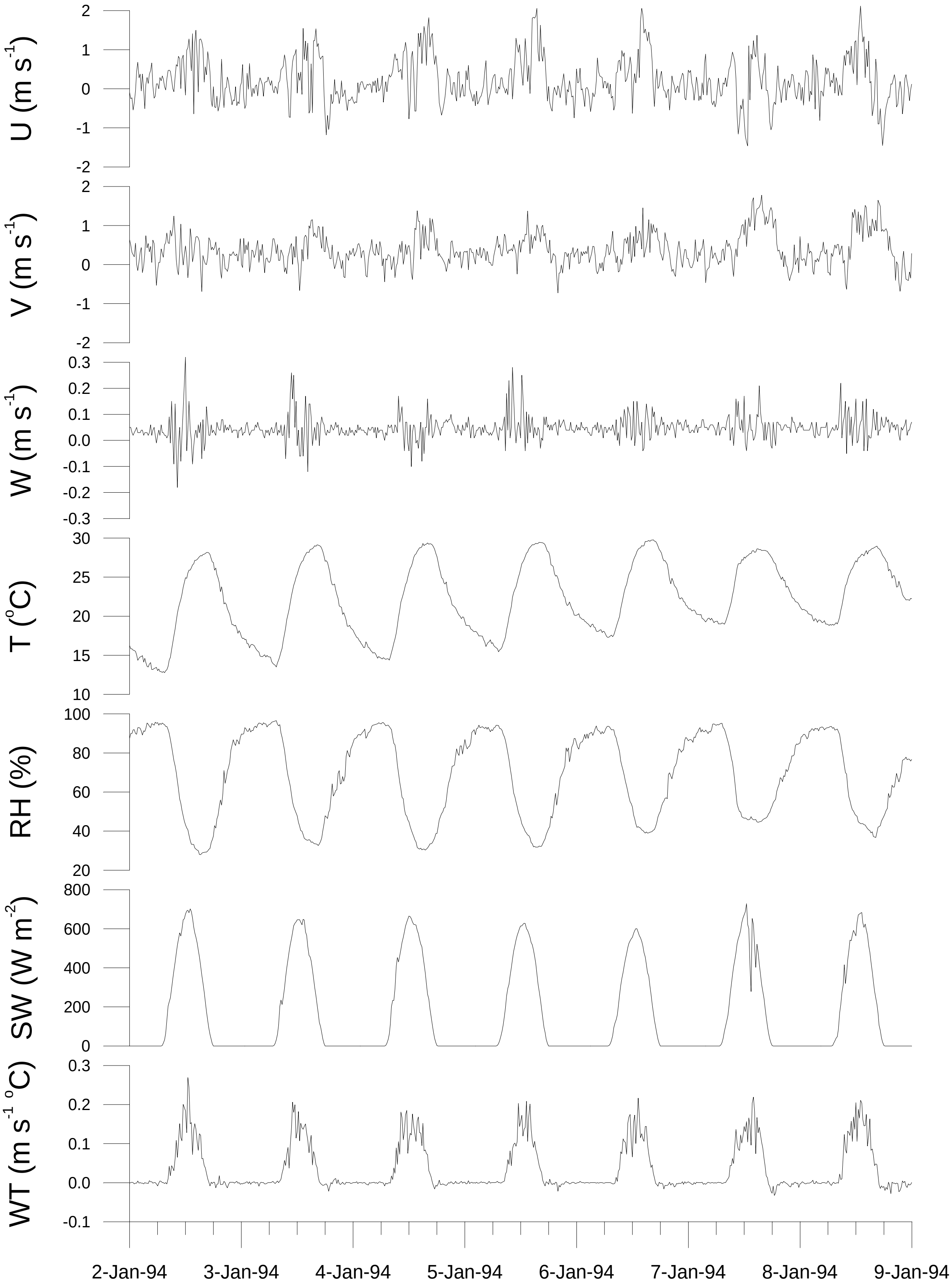

Figure 3. Time series of in-situ meteorological data obtained at 10 m from 2 January to 9 January 1994. From top-to-bottom: Eastward wind velocity, northward wind velocity, vertical wind velocity, air temperature, relative humidity, solar radiation, and covariance of W and T (sensible heat flux).

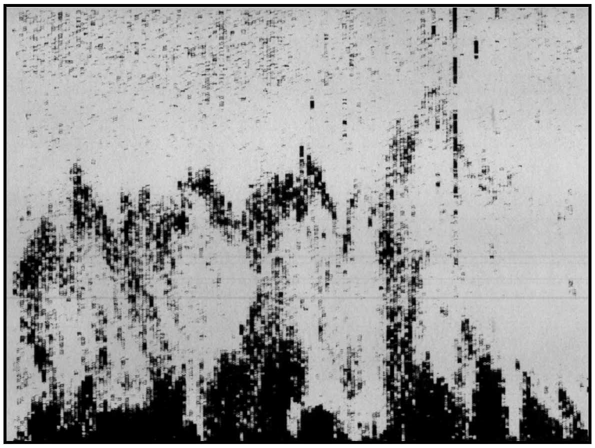

Figure 4. Monostatic sodar plot for 1 January 1994. Horizontal axis is time (positive from left to right) from 1100 to 1200 LST. Vertical axis is height from 0-700 m.

the thermal structure of the atmosphere from the surface up to a height of 700 m. Data were recorded on tabulating computer paper by a dot matrix printer. Figure 4 shows an example of a hour sodar plot.

3.4 *Three-Axis Monostatic Sodar*

A Remtech three-axis monostatic sodar system (model A0), collocated with the monostatic sodar, was used to acquire detailed wind profiles in the lowest several hundred meters of the atmospheric boundary layer. The sodar system was modified in which the Remtech data acquisition system was removed and replaced by Radian Corporation electronics. The antenna array remain unchanged. Profiles of horizontal and vertical wind velocity were obtained as 15-minute averages from 50 m to about 500 m over 25 m intervals.

3.5 *Radar Wind Profiler and RASS*

A 915 MHz radar wind profiler (NOAA designed and built), collocated with the sodars, was used to acquire profiles of horizontal and vertical wind velocity. The output frequency of the remote sensor was readjusted to 924 MHz to insure that Thai mobile telephone communication frequencies of 900 to 915 MHz would not interfere with operation of the profiler. A radio acoustic sounding system (RASS) was used in conjunction with the wind profiler to obtain profiles of virtual air temperature. Three 15-minute wind profiles were acquired each hour by the wind profiler while three 5-minute temperature profiles were acquired each hour by the RASS. The three wind profiles were then combined to create a one-hour average. The same was done for the temperature profiles. Wind data were collected from about 140 m up to about 2500 m over 60 m intervals. Temperature data were collected from about 125 m up to about 1300 m over 60 m intervals. Figures 5 and 6 display one day profile plots of the horizontal wind velocity and virtual air temperature, respectively.

4. SUMMARY

Various sensors were used to acquire air pollution and meteorological data in the vicinity of the EGAT coal burning power plant located in the Mae Moh Valley of northern Thailand. These data have been briefly described in this report. They include SO_2 data from seven surface monitoring stations, in-situ meteorological data taken from a 100-m tower, and remotely sensed data from two sodars, a radar wind profiler, and RASS. When all of these data are combined into one unifying database, a detailed picture of the atmospheric boundary layer is created in time and vertically in space. This data will be useful in examining the atmospheric processes which are responsible for the high pollution fumigation events in the vicinity of the power plant during the cool season. In addition, these data will be very useful for initializing and verifying dispersion models which will attempt to numerically reproduce these events.

5. ACKNOWLEDGEMENTS

The authors wish to thank the many members of the Royal Thai government, the Pollution Control Department, and the Electric Generating Authority of Thailand for their help with the Mae Moh air pollution field study. The authors give sincere thanks to Scott Abbott, Cat Russell, Jim Jordon, Cathy Sharp, and Dominique Ruffieux for all their help in preparing, setting up, and tearing down the NOAA sodar and radar profiling equipment used in the study.

7. REFERENCES

Saengbangpla, S., T. Sumitra, V. Chongvisal, W. Limpaseni, and C. Benyajati, 1981: *Air Pollution Study of Mae Moh Power Plant Project*. Chuan Printing Press, Bangkok, 144 pp.

Saengbangpla, S., T. Sumitra, V. Chongvisal, P. Karasuddhi, W. Limpaseni, and N. Chankow, 1982: *Plume Dispersion Study for Mae Moh Power Plant Units 1 to 9*. Chuan Printing Press, Bangkok, 240 pp.

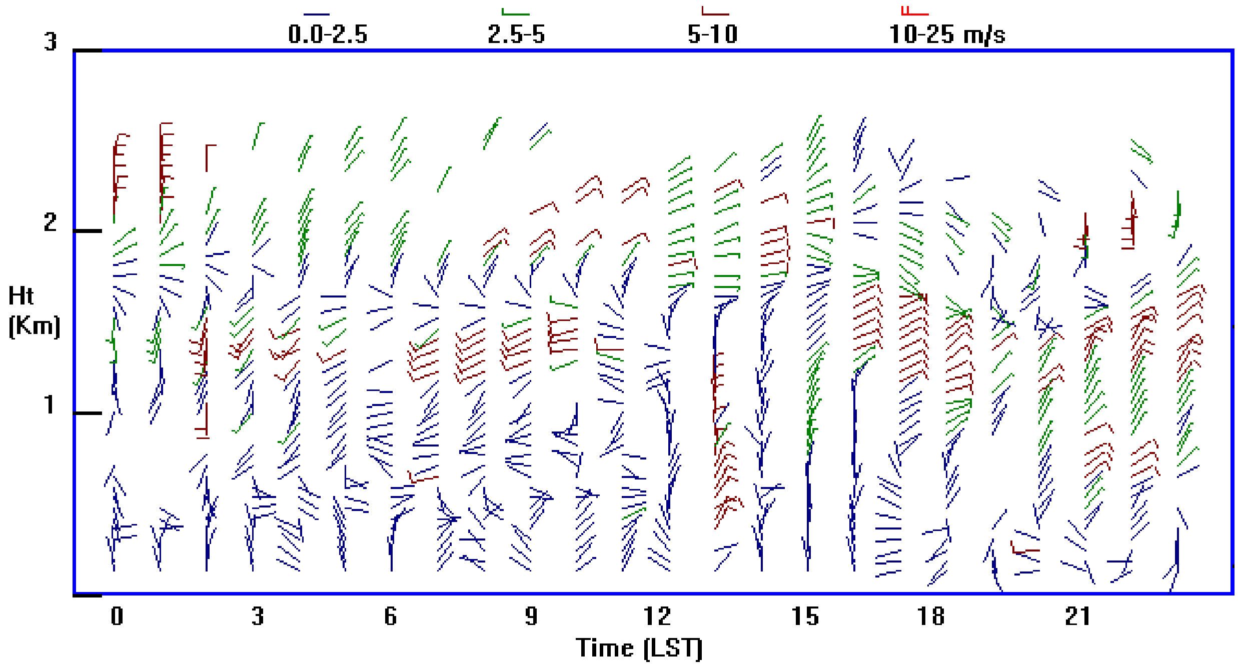

Figure 5. Wind profile data obtained by the NOAA 915 MHz radar on 1 January 1994.

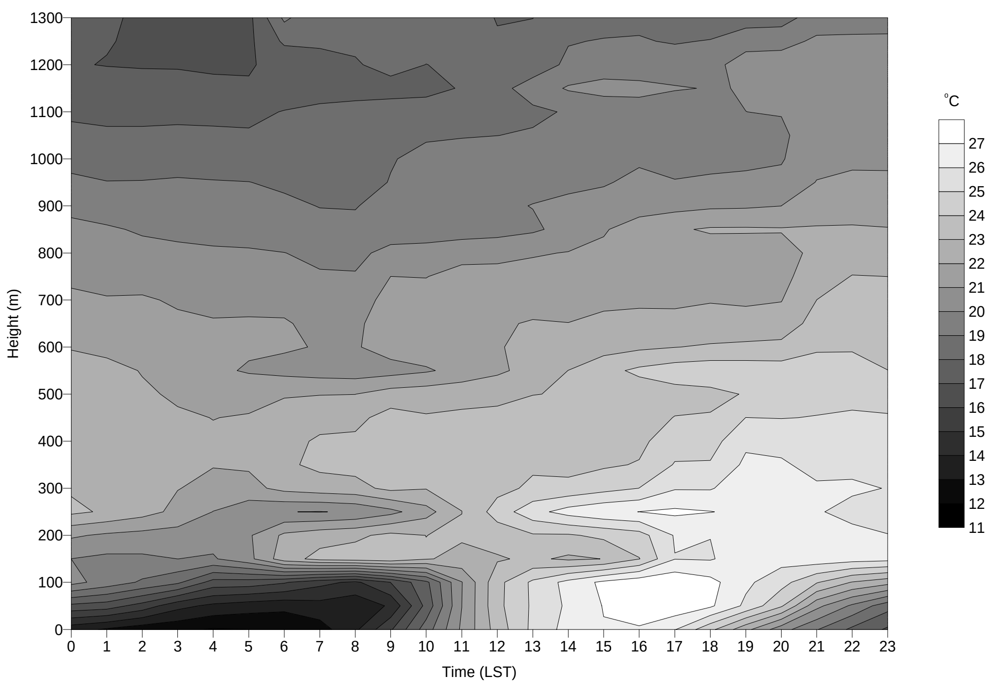

Figure 6. Virtual air temperature profile based on tower and RASS measurements for 1 January 1994.